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A Regional Approach to FIRE HISTORY IN ALASKA

Herman W. Gabriel

and

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U. S. DEPARTMENT OF THE INTERIOR

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Emphasis is now shifting from statewide forest fire control by one organization to regional fire management by a variety of land owners with varying management goals. This change is accompanied by a growing interest in fire history and a need for statistical data that can be used in fire management planning. Statistical data previously reported for wildfire in Alaska were collected for administrative reasons related to fire control and are unsuitable for fire history use in the format usually presented. The authors of this report have organized the available forest fire statistical data according to recognized geographical regions of Alaska to demonstrate that fire data can be stratified in meaningful ways to aid in management decisions. There are ten maps showing fire locations, lightning fires/million acres, percent of each physiographic province burned, and mean fire size.

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INTRODUCTION

Fire history is the chronological record of fires in an area of given size. It is a record of past fires, locations, areal extents, causes, and effects. The quantity and quality of fire history information declines as we go further back in time because the written records of witnessed fires declines, and more reliance must be placed on inference from other sources. Therefore, Quaternary fire history techniques (Wright and Heinselman 1973) must be used to reconstruct the probable fire history of an area from historical sources, tree ring records, and pollen and charcoal stratigraphy.

Studies of the actual occurrence of fire in specific ecosystems are essential for any understanding of the pattern of fire reoccurrence and in turn the effects of fire on the system. Fire history information is used to provide baseline control in temporal and spatial studies of vegetation and the effects of fire on plant community succession. Land managers need such information in resource management planning, and specifically when fire is being considered as a tool to use in meeting resource management objectives.

Numerous studies in recent years have documented the historical occurrence and role of fire in forest ecosystems outside of Alaska. Alexander (1979, 1980) has provided a bibliography and resume of current fire history investigations. Some studies describe the incidence of charcoal in beds of lakes and wetland sediments dating back 1,000 years or more (Cwynar 1978, Swain 1973, 1978). Others deal with more recent fire history, generally based on an examination of fire-scarred trees (Heinselman 1973, Arno 1976, Gabriel 1976, Tande 1979), or on the available fire records in recent decades (e.g., Wein and Moore 1977). The most comprehensive investigations using Quaternary fire history techniques were conducted in Minnesota and northwest Montana. These include analysis of individual fire reports, tree-ring records, historical source materials, historical geography, anthropology, and pollen and charcoal stratigraphy. Examples for Minnesota include Heinselman (1973) and Swain (1973) and for Montana Arno (1976), Gabriel (1976), Mehringer et. al. (1977), and Barret (1980).

Two problems inherent in the current literature on fire history in North America are inconsistent use of terms for specific fire history concepts, and the difference in size between study areas. The material presented here is intended to help define the size of future study areas in Alaska. Definitions agreed upon at a national fire history workshop (Romme 1980) will be used in this paper.

Wildfire has been recognized as an important force in the Alaskan environment for many years. The Alaska Fire Control Service was organized in 1939 and charged with the prevention and suppression of fire in the public domain of Alaska. Reporting of statistics on fire occurrence and size began in 1940. Several authors have compiled and analyzed statewide statistics useful for reporting the magnitude and effectiveness of the fire control job over the years (Hardy and Franks 1963; Barney 1969, 1971a).

Emphasis is now shifting from statewide fire control by one organization to regional fire management by a variety of landowners with varying management goals. This change is accompanied by a growing interest in fire history and a need for statistical data that can be used in fire management planning. One problem is that the statistical data reported by Barney (1969, 1971a) and others (Barney and Stocks 1979, Stocks and Barney 1981) for wildfire in Alaska were collected for administrative reasons related to fire control and are unsuitable for fire history use in the format usually presented.

Barney and Stocks (1979) identified difficulties in interpreting and using Alaska fire statistics for fire history purposes and pointed out that the size of administrative protection zones and reporting units have changed from time to time as a function of management or political priorities. Suppression policies have also changed, detection methods have improved, and other factors which are not reported with the statistics make it difficult to normalize the data so that comparisons can be made. Hardy and Franks (1963) also noted the bias in the way fires were reported and how that had changed over time. Viereck and Schandelmeier (1980) reviewed the literature on the effects of fire in Alaska but found almost nothing on fire history. They pointed out the need for good fire records and the problems in terminology which make it difficult to determine from fire reports just what vegetation types were burned. What has passed for fire history in Alaska is largely anecdotal and no studies to date have reconstructed fire history using state-of-the-art techniques.

OBJECTIVES

The objectives of this study were (1) to organize the available fire statistical data according to recognized geographical classification schemes, (2) to demonstrate that fire data can be stratified in meaningful ways to aid in management decisions, and (3) to make the

definitions and methodology of fire history studies known to a wider spectrum of users with the hope of standardizing the terminology in Alaska.

STUDY AREA

This study began as an interest in methods to identify and segregate variation in the natural fire regime within the area of Alaska for which the Bureau of Land Management was beginning to prepare cooperative fire management plans in 1979. Thus, the area treated in this paper is that portion of Alaska west of 141° West longitude (the boundary with the Yukon) and north of an arbitrary line between the towns of Kodiak and Dillingham (Figure 1). This includes the area for which long-term fire statistics are available, but excludes the southeast panhandle, the Aleutian Islands, and the Alaska Peninsula where lightning caused fires are rare. The study area covers approximately 588,000 square miles (357 million acres) and is larger than the combined areas of the states of Montana, Idaho, Wyoming, Colorado, and Utah. That portion of the U.S. is subdivided geographically into 5 states, 43 national forests, and 23 BLM districts with statistics on wildfires available for each unit. There has been no such stable subdivision of Alaska. Fire statistics usually have been reported for "interior Alaska," the core of the area covered by this study, and "southeast Alaska."

METHODS

Available wildfire statistics for Alaska were gathered from published reports and Bureau of Land Management files and reviewed. Original fire reports for all fires suppressed by BLM forces since the 1950's are still on file in the BLM-Alaska State Office, and data from individual fire reports for the period from 1957 to 1979 had been entered into the BLM computer data base. The location of 8,316 fires over a 23 year period could, therefore, be plotted by the computer on suitable base maps to show geographical distribution by ignition source, fire size, or date.

Locations of all lightning-caused fires were plotted on one map overlay and man caused fires were plotted on another.

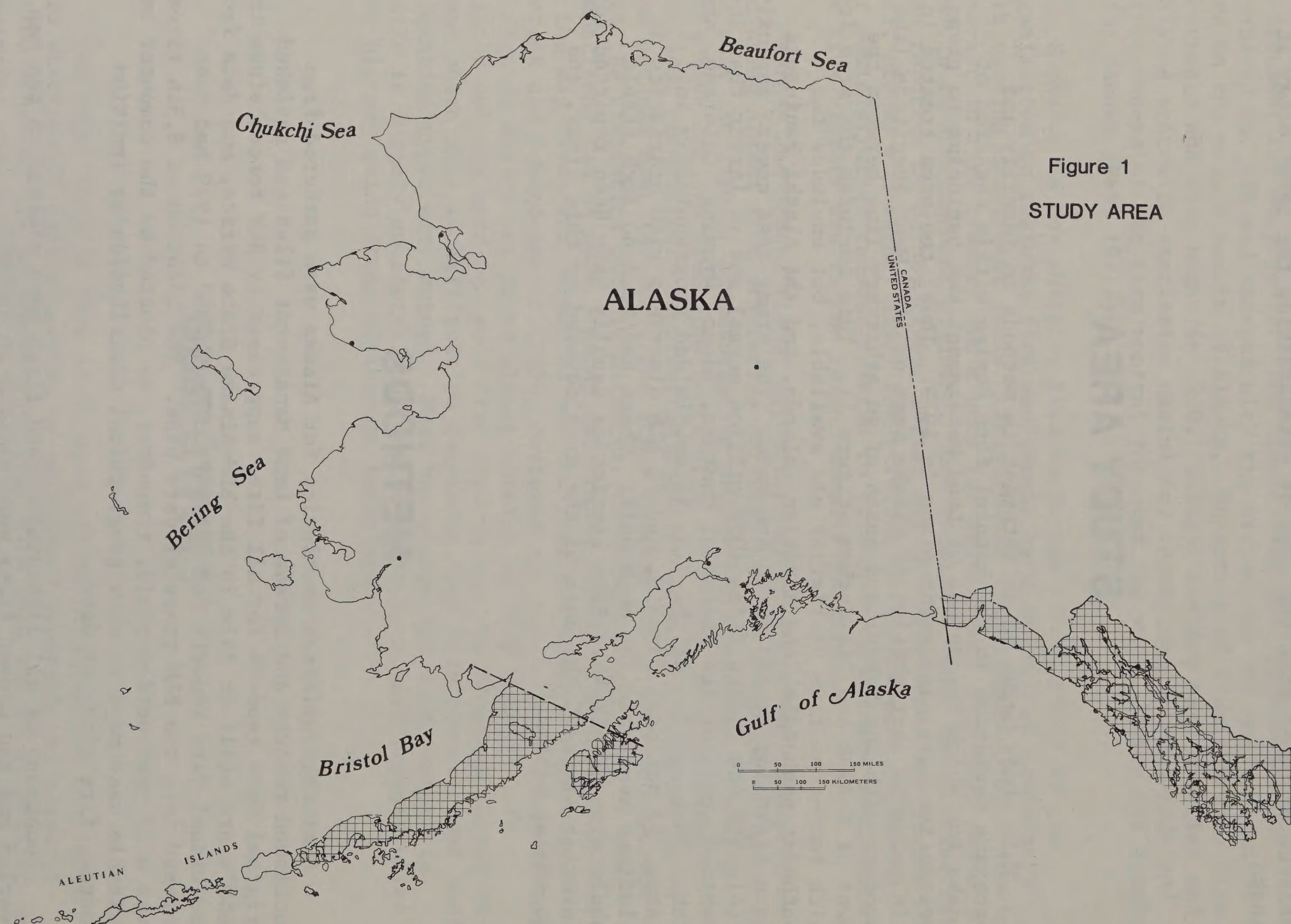

Figure 1

STUDY AREA

Lightning fire locations for each of the 23 years from 1957 through 1979 were then plotted on 23 individual overlays at a scale of 1:2,500,000 for use with the Alaska "Series E" maps. To determine the utility of the various geographic classification schemes for stratifying fire data, those overlays were placed over maps of (1) Alaska Planning regions, (2) Alaska fire weather zones, (3) physiographic provinces, and (4) physiographic sections. The various maps used had a nominal scale of 1:2,500,000 but had apparently been constructed from different projections which made it impossible to fit overlays from one projection exactly to another one. This required constant checking of borderline fires against the reported location to assure placement in the proper geographic unit. The area of each geographic unit was measured with a planimeter.

The occurrence and size of each fire was tabulated for each year in each geographic unit. Those data were then compiled into tables for comparison of fire frequency and area burned by geographic unit. In order to normalize the data for purposes of comparison, they are shown as fires/million acres/23 years, percent of area burned in 23 years, and mean fire size for each geographic subdivision.

Area in acres is used to make easier comparisons with earlier reports.

RESULTS

STATEWIDE DATA

Table 1 summarizes the available statistical data on wildfires in interior Alaska from Hardy and Franks (1963), Barney (1969, 1971a), and fire reports from the BLM Alaska State Office (BLM 1976, 1978, 1979). These data show that 11,048 fires burned some 30,302,222 acres in 40 years with an average of 757,556 acres burned per year. Lightning accounted for 38% of the recorded fires and 83% of the area burned.

It is evident that the reported number, cause, and area burned by wildfires each year has varied over this 40-year period. Unfortunately, much of the variation is an artifact of the detection and reporting methods and of the size of areas protected from year to year. The compilation and reporting of statistics on fire occurrence began in 1940, but for several years lightning was discounted as a cause of

Table 1. Number of fires and area burned, by year and cause, for interior Alaska, 1940-1979.*

Year	Lightning-Caused Fires					Man-Caused Fires					All Fires		
		% of All	Acres Burned				% of All	Acres-Burned				Acres Per	Total
	Number	Fires	Per Fire	Total	% of All	Number	Fires	Per Fire	Total	% of All	Number	Fire	Acres
1940	0	0				130	100				130		4,500,000
1941	0	0				116	100				116		3,645,774
1942	0	0				78	100				78		452,510
1943	40	21	Not Available			154	80	Not Available			194		666,773
1944	18	25				55	75				73		110,604
1945	30	42				41	58				71		117,313
1946	52	40				78	60				130		1,436,597
1947	32	20				127	80				159		1,429,896
1948	21	16				113	84				134		33,676
1949	7	13				46	87				53		17,933
1950	27	12		445,595	22	197	88		1,612,222	78	224	9,187	2,057,817
1951	27	10		17,484	8	244	90		202,210	92	271	811	219,694
1952	11	8		14,556	20	125	92		59,245	80	136	543	73,801
1953	75	26		381,143	82	210	74		85,605	18	285	1,638	466,748
1954	63	24		1,347,990	97	199	76		41,930	3	262	5,305	1,389,920
1955	26	14		10,467	28	164	86		26,765	72	190	196	37,232
1956	64	28	6,980	446,746	94	162	72	184	29,857	6	226	2,109	476,593
1957	160 (159)	41	31,432	5,029,081	99	231 (202)	59	91	20,915	1	391	12,915	5,049,661
1958	92 (87)	33	2,485	228,648	72	186 (156)	67	476	88,567	28	278	1,141	317,215
1959	200 (178)	62	2,904	580,830	97	120 (113)	38	131	15,744	3	320	1,864	596,574
1960	62 (63)	26	527	32,657	37	176 (152)	74	310	54,523	63	238	366	87,180
1961	31 (31)	26	41	1,283	25	86 (73)	74	44	3,817	75	117	44	5,100
1962	53 (53)	52	714	37,828	97	49 (42)	48	23	1,147	3	102	382	38,975
1963	79 (81)	41	125	13,859	85	115 (110)	59	21	2,431	13	194	84	16,290
1964	63 (62)	38	39	2,430	71	101 (76)	62	10	1,000	29	164	21	3,430
1965	30 (31)	20	97	2,918	41	118 (99)	80	35	4,175	59	148	48	7,093
1966	73	22	8,811	643,205	98	251	78	45	11,234	2	324	2,020	645,439
1967	76	35	1,370	104,162	96	139	65	35	4,843	4	215	507	109,005
1968	265	59	3,807	1,008,911	99	180	41	23	4,310	1	445	2,277	1,013,301
1969	126	24	21,875	2,756,279	65	389	76	3,793	1,475,541	35	515	9,509	4,231,826
1970	140	28	765	107,108	94	347	72	18	6,378	6	487	233	113,486
1971	240	51	4,416	1,059,921	99	232	49	39	9,187	1	472	2,195	1,069,108
1972	472	73	2,042	963,999	99	173	27	12	2,248	1	645	1,498	966,247
1973	123	37	410	50,480	84	213	63	43	9,336	16	336	178	59,816
1974	384	49	1,680	645,192	97	398	51	44	17,768	3	782	848	662,960
1975	134	39	643	86,208	67	210	61	198	41,637	33	344	372	127,845
1976	227	40	241	54,885	79	345	60	41	14,234	21	572	121	69,119
1977	401	64	5,716	2,292,431	99	222	36	15	3,377	1	623	3,685	2,295,808
1978	82	25	70	5,809	75	242	75	8	1,948	25	324	24	7,757
1979	188	67	2,050	385,321	99	92	33	36	3,341	1	280	1,388	388,662
Total	4,194			18,310,680		6,854			3,825,678		11,048		30,302,222
Average		38	4,348		83		62	389		17		2,151	

*1. 1940-1955 from Table 34-35 Hardy and Franks (1963).
2. 1956-1965 from Barney (1969). No. in () are are counts from BLM fire statistics ASO-ADP.
3. 1969-1978 from USDI-BLM (1978). $\pm$ cols. 1, 4, 6, 9, 11, 131.
4. 1967-1968 from USDI-BLM (1976). $\pm$ cols. 1, 4, 6, 9, 11, 131.
5. 1966, 1979 BLM-ADP printout (1979).
6. Data from 1977-1979 do not include data for State lands or National Forest lands.

Note: For the first three years lightning was discounted as a cause of fires and none were reported.

fires (Hardy and Franks 1963). A bias toward man-caused fires remained into the mid 1950's because fire detection and reporting were tied to the available road system. The fires found near towns and villages were usually man-caused, and many remote lightning fires went undetected and unreported during that period. The actual number of lightning fires and area burned prior to the mid 1960's must be greater than that shown in the table, but there is no way of knowing how much greater.

The data on acres burned from 1960 through 1965 appear anomalous when compared to the other data in Table 1. People familiar with the situation have stated that there was a real difference in the weather during that period. J.H. Richardson (personal communication) described the years with which he was familiar as follows:

1964 was cool and damp with little lightning and only one project fire. The suppression force was medium compared to that of 1940 and 1980.

1965 was another rainy year.

1966 was a dry year with late season project fires from Galena to Goldstream to Chicken which burned until snowfall.

1967 started off with many large lightning fires, but then the rains came which resulted in the Fairbanks flood.

1968 was a dry year with many lightning-caused project fires. The fire organization was overwhelmed.

1969 was the classic bad year that caused changes in the whole fire fighting budget and organization from 1970 on. The fire season began in March with carry-over fires before the normal fire suppression manpower was in place. A series of lightning storms started fires that completely smoked in the interior and stopped virtually all aircraft use on fires. Consequently, the fires became large. Finally, the Swanson River fire started in August when fire suppression forces were exhausted.

1970 saw a combination of new fire forces, new equipment, and reasonable luck.

1971 had high acreage burned due to a few escaped fires.

Even with airplanes available for fire detection and suppression, the size of areas protected fluctuated with changing budgets and protection policies through much of the 1960's (Barney and Stocks 1979). With more stable budgets and effective detection methods available since 1969, the later data should more accurately show the occurrence of lightning caused fires in interior Alaska.

Although one agency, the Bureau of Land Management, has been responsible for fire detection and control during most of the 40 year period, published reports do not always agree on the number of fires or the acreage burned in any one year. The figures in parentheses in Table 1 for the years 1956 to 1969 illustrate the problem where several reports overlap. The blank spaces in Table 1 indicate that statistics for some years are incomplete and the basic data are not readily available in files in Alaska. Since 1979, there has been a constantly changing data base as acreage has been transferred from BLM to the State of Alaska and to the Alaska Native corporations. Therefore, there is no longer one source for fire statistics or one complete set of data for the later years.

Statistics from 1968 to 1979 are the most complete and most reliable. However, the data from individual fire reports for the period from 1957 through 1979 were available in the BLM files and had been entered into the BLM computer data base. The location of 8,316 fires could, therefore, be automatically plotted on suitable base maps to show geographical distribution by ignition source, fire size, or date.

Plotting the fire locations reveals two distinct patterns of distribution. Figure 2 is a plot of lightning fire locations that shows them distributed in a broad belt between the Brooks Range to the north and the Alaska Range to the south. The lightning fire occurrence shows no correlation with human settlements and probably reflects the "natural" occurrence of fire many decades into the past.

Figure 3, on the other hand, shows man-caused fires distributed along the road system and near population centers. This pattern must certainly have changed over time as human settlement and activity moved from place to place. If such a map could have been made in 1910, it might have shown man-caused fires occurring along the rivers which were the chief transportation routes before roads were built. Both lightning and man-caused fire information are important in constructing the fire history of an area, but for the purposes of this analysis we have used only the 3,650 lightning fires reported from 1957 through 1979.

DEFINITIONS

The following terms are frequently used when speaking of fire history and/or fire effects. The definitions are from Romme (1980) with the preferred term first and synonyms in parentheses:

- Fire Occurrence (or Fire Incidence) is one fire event taking place within a designated area during a designated time. There are no units of measurement; either yes, a fire occurs, or no, a fire does not occur.

- Fire Interval (or Fire Free Interval or Fire Return Interval) is the number of years between two successive fires documented in a designated area (i.e., the interval between two successive fire occurrences). The size of the area must be clearly specified. Unit of measurement is years.

- Mean Fire Interval is the arithmetic average of all fire intervals determined in a designated area during a designated time period. The size of the area and the time period must be specified. Unit of measurement is years.

- Fire Frequency is the number of fires per unit time in some designated area (which may be as small as a single point). The size of the area must be specified. Expressed as number/time/area.

- Fire Cycle or Fire Rotation is the length of time necessary for an area equal to the entire area of interest to burn. The size of the area of interest must be clearly specified. Expressed as years/area.

Using the available statistical data on fires in interior Alaska from Table 1 with the fire history definitions gives the following results:

- Fire Occurrence. Yes, a fire has occurred within interior Alaska, in fact, a fire has occurred each year since 1940.

- Fire Interval. The interval between two successive fires is less than one year in the 357 million acres of interior Alaska.

- Mean Fire Interval. The mean fire interval is less than one year for 40 years of record in the 357 million acres of interior Alaska.

- Fire Frequency is 276 fires per year per 357 million acres.

- Fire Cycle is about 471 years to burn 357 million acres.

It is obvious that there can be no meaningful statistics on fire history on a generalized statewide basis, and that one can not realistically speak of "the fire history of Alaska." To be useful for fire history studies, statistical data must be subdivided by time and

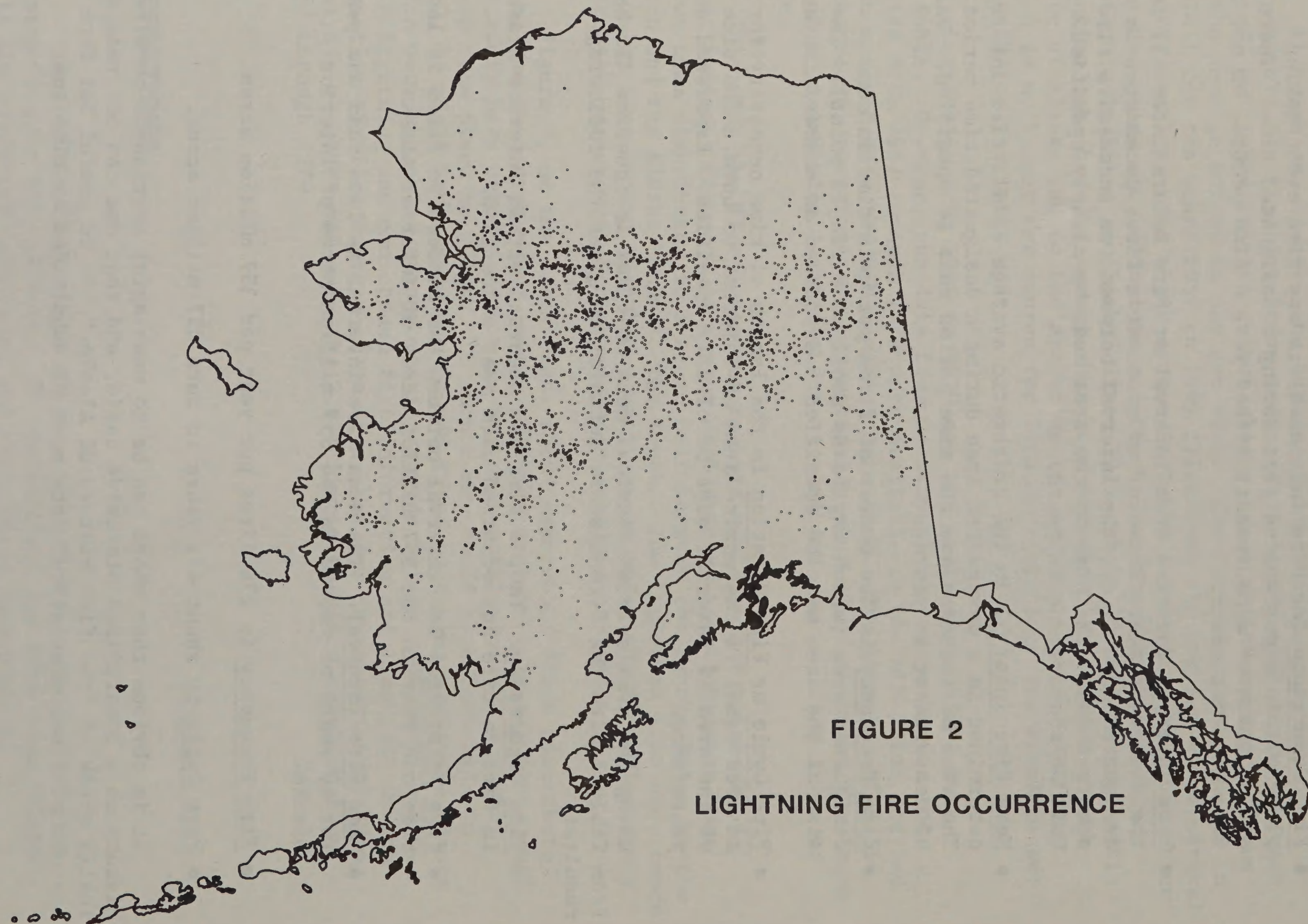

FIGURE 2

LIGHTNING FIRE OCCURRENCE

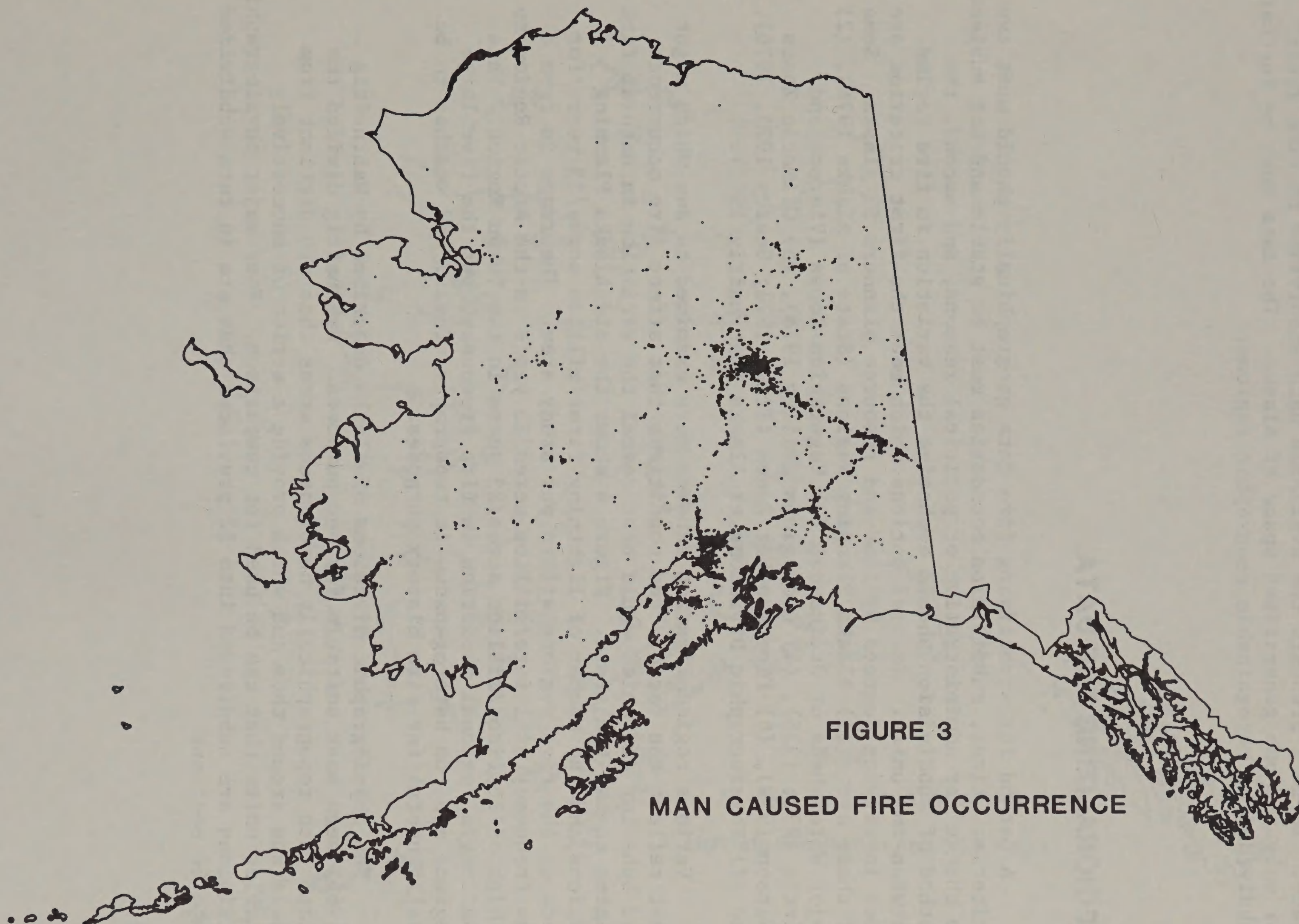

FIGURE 3

MAN CAUSED FIRE OCCURRENCE

space. Table 1 presents the available data subdivided by time (year) for only the one generalized space of Alaska. The data must be further subdivided by recognizable geographic regions.

REGIONALIZING THE DATA

A method for stratifying fire data geographically should meet two criteria: first, subdivision boundaries must be stable and not subject to change for administrative or political reasons, and second, the method of subdivision should emphasize the variation in fire regime between the units. Several options which meet the first criterion are used in varying degrees by land and resource planners in Alaska. Some of these are: (1) Alaska Planning Regions (State of Alaska 1974), (2) Major Watersheds or drainages, (3) Vegetation Zones (Viereck and Little 1972, 1975), (4) Ecoregions (Bailey 1978), (5) Climatic Zones (Watson 1959), (6) Fire Weather Zones (Trigg 1971; Searby 1975, 1976), and (7) Physiographic Divisions of Alaska (Wahrhaftig 1965).

Various regionalization schemes were examined to see which might best reflect the factors and conditions that affect fire occurrence and behavior and which would best reveal the variation in natural fire regime across the state. Figure 4 shows the six Alaska Planning Regions and the number of lightning fires/million acres/23 years for each of the five regions within our study area. The range is from a low frequency of 1 fire/million acres/23 years in the Arctic Region to a high of 26 fires/million acres/23 years in the Yukon Region. This confirms a regional variation in fire frequency, but the five large regions are too heterogeneous in topography, fuels, and weather to be really useful for fire history purposes.

The physiographic divisions of Alaska described by Wahrhaftig (1965) seem most suitable for our purposes. Wahrhaftig divided the state into topographically homogeneous areas that are distinct from the areas around them and which provide a series of successively smaller units that can be used for comparison. Four major physiographic divisions are subdivided into 12 provinces that are in turn subdivided into 60 sections.

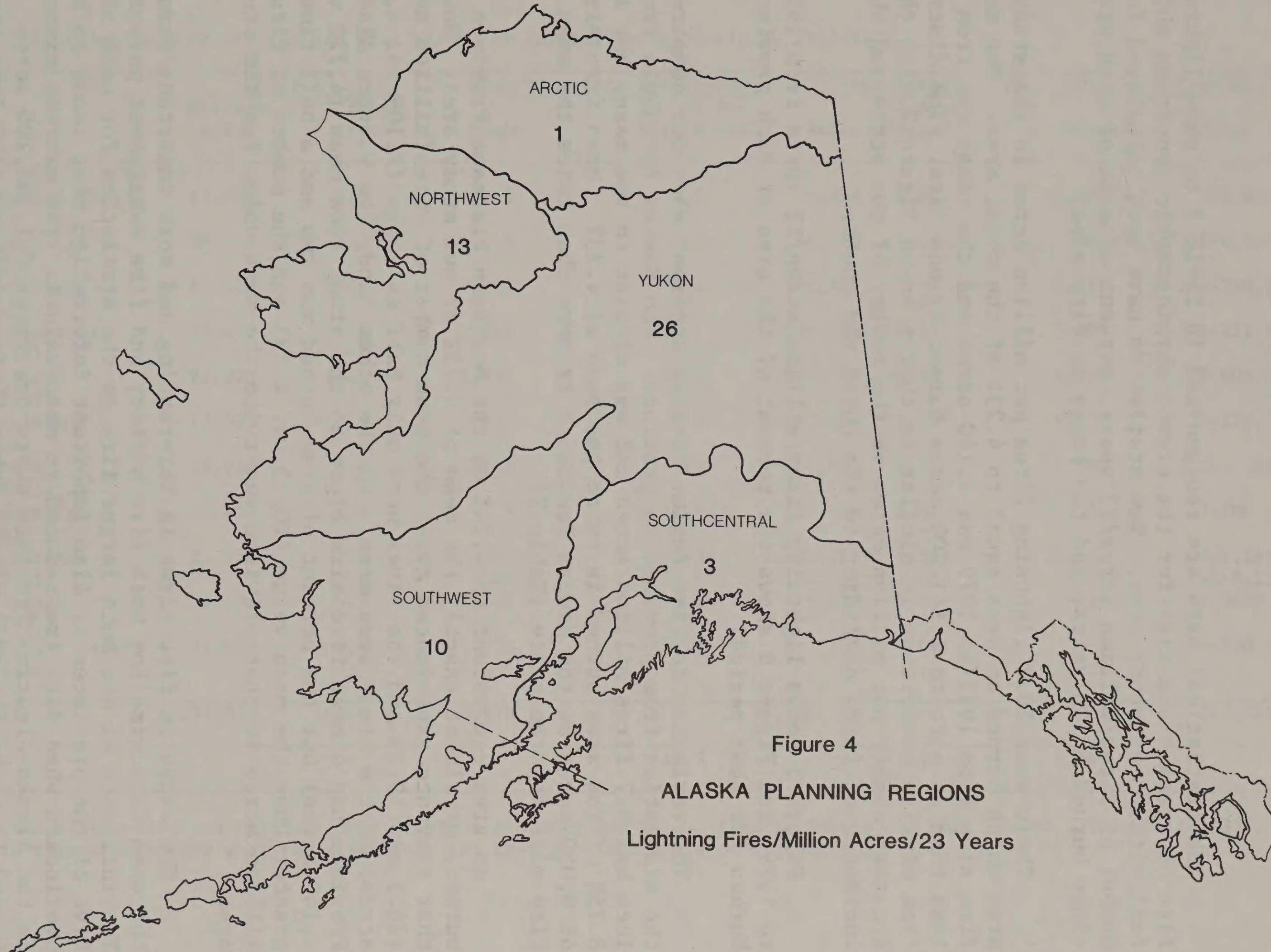

Figure 4

ALASKA PLANNING REGIONS

Lightning Fires/Million Acres/23 Years

OCCURRENCE OF LIGHTNING FIRES BY PHYSIOGRAPHIC PROVINCE

The statistical data are reorganized in Table 2 to show lightning fire occurrence and size for the eleven physiographic provinces which fall within our study area. New statistics have been calculated for number of fires/million acres/23 years, percent of area of each province burned in 23 years, and the range in fire size.

There were 10.2 lightning fires per million acres in the study area which burned an area equal to 4.23% of the total area. The mean fire size from 1957 to 1979 was 4,140 acres and the range was from less than an acre to 1,161,200 acres burned by one fire. The distribution of fire occurrence is similar to that seen on Figure 2 with the greatest number per million acres in the center of the state and the incidence of fires declining to the north and south.

Figure 5 shows lightning fires/million acres/23 years from 1957 to 1979, and Figure 6 shows the percent of the area of each province burned for that period.

The variation in fire regime becomes apparent when one compares the statistics from province to province. The Seward Peninsula Province had 9.7 fires/million acres and was closest to the mean, but its 8.75% of the area burned is twice the mean of 4.23%. Mean fire size of 9,030 acres on the Seward Peninsula is more than twice the mean fire size for the state (Table 2).

An area equivalent to 4.24% of the Northern Plateaus Province burned, or almost exactly the mean of 4.23% of our study area. However, that province experienced twice the mean number of fires/million acres (20.1 vs. 10.2) and the fires were only half as large (2,109 vs. 4,140 acres) as the study area mean. On the other hand, the Western Alaska Province had a mean fire size close to the study area mean (4,722 vs. 4,140 acres) but the percent of area burned was two and a half times greater than the mean value (10.33 vs. 4.23) and the number of fires/million acres in that province was twice the mean value for the study area.

The range in fire sizes is interesting and more important than the mean fire size for both fire history and fire management purposes. The influence of one much larger fire on the statistics for each of five of the provinces is also important information that tends to be overlooked when data are reduced to mean values. The extreme example is the Alaska-Aleutian Province where one fire of 1,161,200 acres burned 43 times the area of all other 45 fires of record. Removing that one fire from the tabulation does not greatly change the number of fires/million acres, but it radically changes the mean fire size and percent of area burned in that province.

Table 2. Lightning fire occurrence and area burned by Physiographic Province, 1957-1979.

Province (Section)	Area: Million Acres	Area: % Total Area	Lightning Fire Occurrence: Number	Lightning Fire Occurrence: Number Per Mil. Acres	Area Burned: Acres	Area Burned: % Area Burned	Fire Size (Acres): Mean	Fire Size (Acres): Range
Arctic Coastal Plain (1)	17.557	5.0	3	0.2	8,408	0.04	2,803	3-8,400
Arctic Foothills (2)	28.362	7.9	9	0.3	4,148	0.01	461	1-4,000
Arctic Mountains (3-7)	41.598	11.7	224	5.4	992,087	2.38	4,429	1-270,000
Northern Plateaus (8-16)	52.672	14.7	1,061	20.1	2,238,093	4.24	2,109	1-251,520
Western Alaska (17-32)	91.029	25.5	1,993	21.9	9,410,156	10.33	4,722	1-803,470
Seward Peninsula (33)	13.505	3.7	131	9.7	1,182,894	8.75	9,030	1-270,000
Bering Shelf (34-35)	29.980	8.4	113	3.8	77,975	0.26	690	1-10,025
Ahklum Mountains (36)	9.454	2.6	9	1.0	489	0.01	54	2-200
Alaska-Aleutian (37-41)	27.552	7.8	46* (45)	1.7* (1.6)	1,188,207* (27,007)	4.31* (0.09)	25,831* (600)	1-1,161,200 (1-8,120)
Coastal Trough (42-52)	22.689	6.3	48	2.1	6,603	0.03	138	1-5600
Pacific Border Ranges (52-58)	22.689	6.4	13	0.6	118	0.01	9	1-100
Total	357.037	100.0	3,650		15,109,178			1-1,161,200
Mean				10.2		4.23	4,140	

*Figures for Alaska-Aleutian Physiographic Province are high due to one fire in Section 41 that burned 1,161,200 in 1957. Values in parentheses show what the statistics for that province would be without that fire.

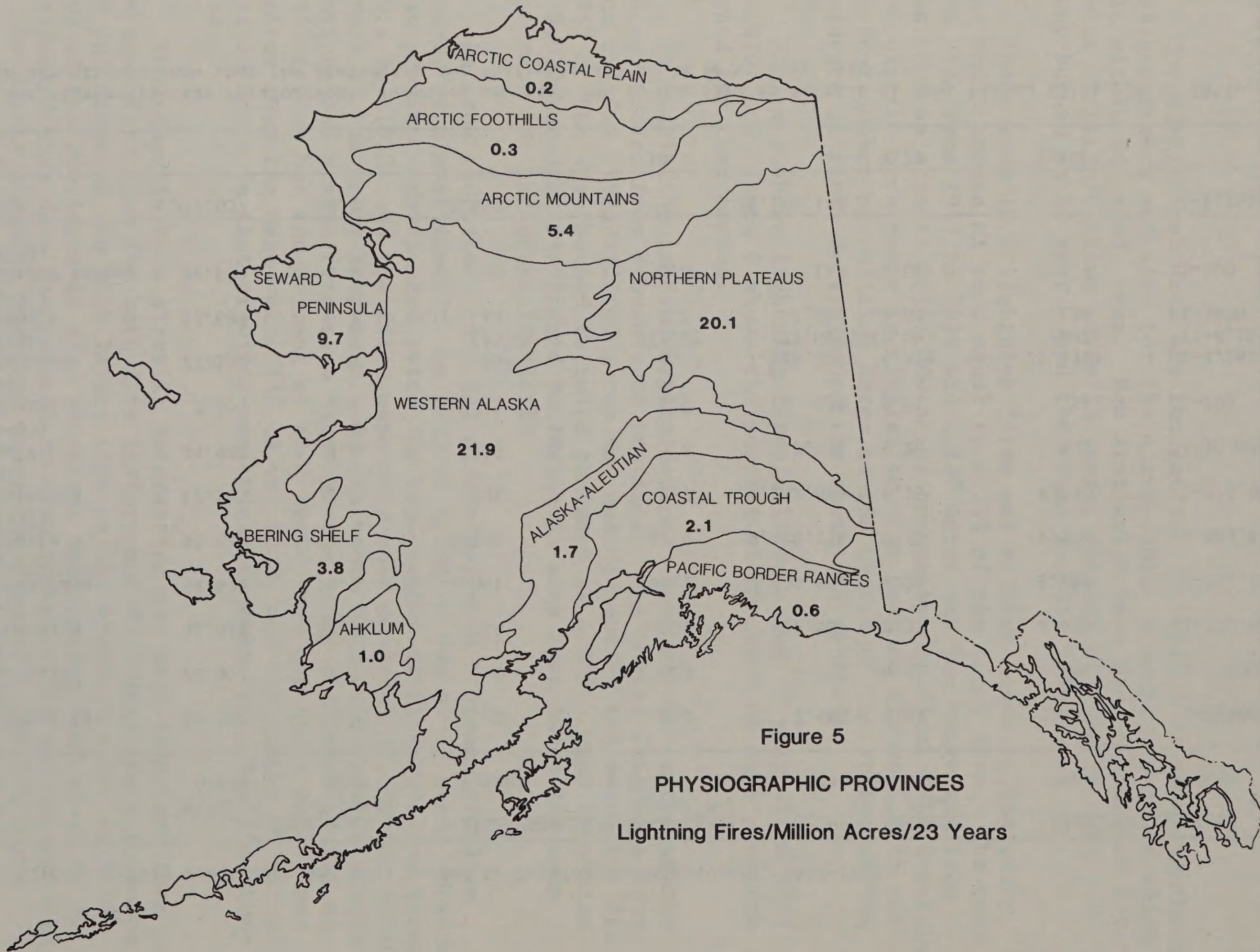

Figure 5

PHYSIOGRAPHIC PROVINCES

Lightning Fires/Million Acres/23 Years

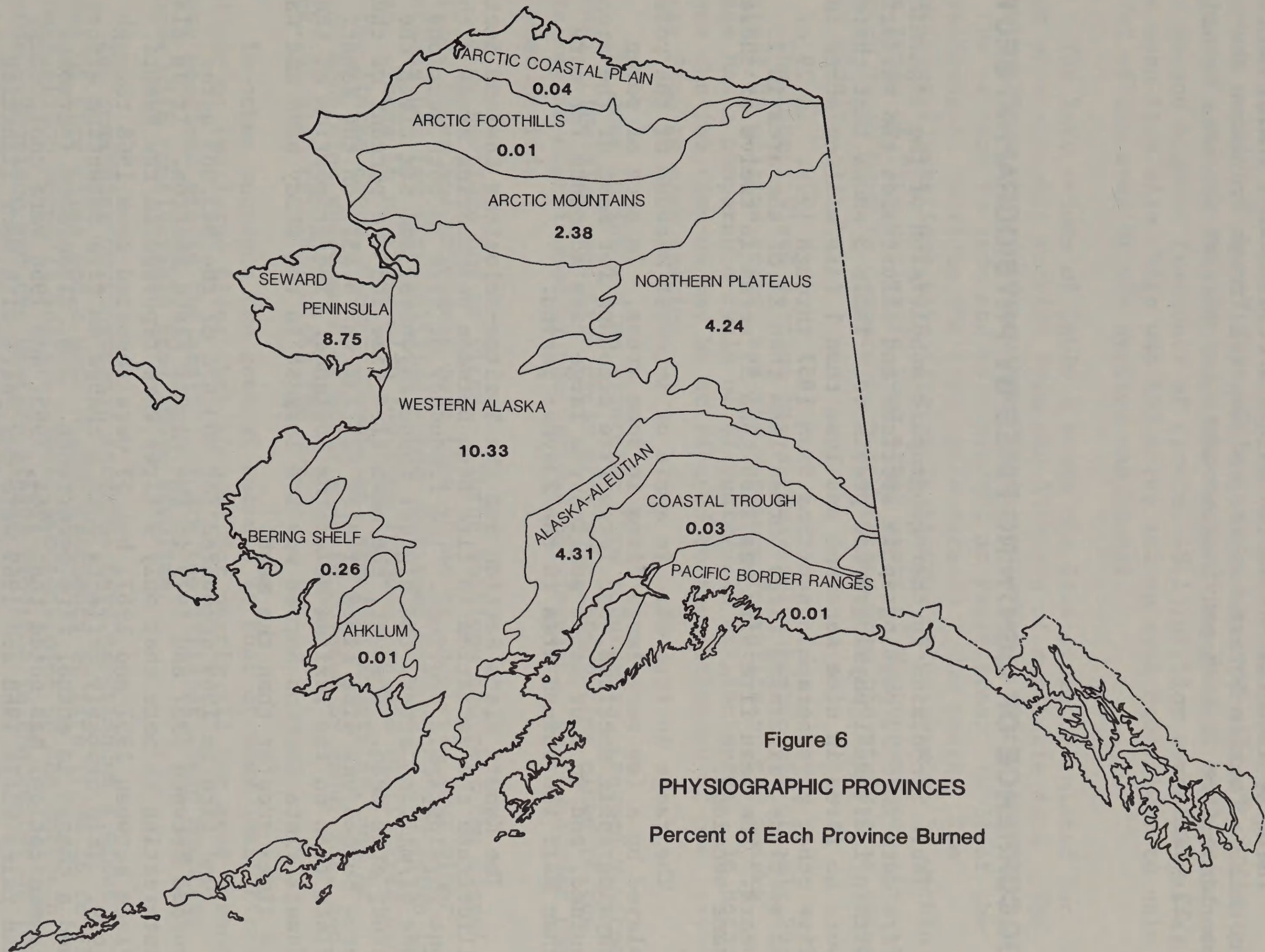

Figure 6

PHYSIOGRAPHIC PROVINCES

Percent of Each Province Burned

There is a similar situation in the Arctic Coastal Plain, Arctic Foothills, Pacific Border Ranges, and Coastal Trough Provinces where one large fire in each province accounts for most of the area burned in 23 years.

OCCURRENCE OF LIGHTNING FIRES BY PHYSIOGRAPHIC SECTION

Table 3 contains further geographic subdivision of the lightning fire data into 53 physiographic sections and illustrates the variation within individual physiographic provinces. Table 3 shows that there were no fires in nine sections and less than 1 fire/million acres in five other physiographic sections from 1957 through 1979. In 29 of the 53 sections, lightning fires burned less than 1% of the area in 23 years. The mean fire size was less than 55 acres in twelve of those same sections.

The range in fire size is again of interest because of the role played by a few very large fires in some areas. In each of seven physiographic sections, one large fire accounts for most of the area burned, and in four other sections, a large fire accounts for more than half the burned area in the 23-year period.

The Kanuti Flats Section and the Tozitna-Melozitna Lowland Section illustrate the variation in fire size between neighboring areas within one physiographic province. The frequency of fire in both sections was 61/million acres, the highest found anywhere, and six times the study area mean. However, the mean fire size and the percent of the area burned was nine times greater (78.13% vs. 8.83%) on the Kanuti Flats than on the Tozitna-Melozitna Lowlands. The proportion of the Kanuti Flats Section burned was the largest in the study area and was 18 times greater than the mean.

One fire in 1969 accounted for 803,470 of the 843,805 acres burned between 1957 and 1979 in the Kanuti Flats Section. It is also interesting to note that only 9 fires were reported in the Kanuti Flats between 1957 and 1967, but 57 were reported from 1968 through 1979. This probably reflects both a change in fire detection effort and a change in actual fire occurrence. J.H. Richardson (personal communication) has noted that 1964, 1965, and 1966 were cool, damp, and rainy while 1968 and 1969 were dry years with many lightning fires.

Figure 7 shows how the highest occurrences of lightning fire were concentrated in the north central part of the state and decrease in

all directions from there. The proportion of each physiographic section burned is shown in Figure 8 and the mean fire size is shown in Figure 9. Notice that although the Rampart Trough Section experienced the second highest frequency of fire at 48.15/million acres/23 years, the mean fire size there was 153 acres and an area equivalent to only 0.74% of the area of the section was burned.

The last column of Table 3 shows the fire cycle calculated for each physiographic section from the 23 years of available data. The fire cycle is the time necessary for an area equal to the total area of the section to burn and is expressed as years/area. In 31 of the physiographic sections the fire cycle exceeds 1,000 years. The remaining 22 sections have fire cycle figures which seem to be within the range of fire cycles in some other parts of North America, although it is hard to compare such statistics when the study area sizes vary widely.

The Kanuti Flats section has a remarkably short cycle of only 29 years/1.08 million acres, and the Northern Foothills of the Alaska Range has a comparable cycle of 47 years/2.43 million acres. In both cases the low figures may be attributed to the influence of one very large fire in each section.

The data in Table 3 on lightning fire occurrence, frequency, area burned, fire size, and fire cycle give some interesting clues to the fire regime experienced by the various physiographic sections over the 23 year period.

Nine sections had no fires. Three sections had very few fires/million acres and none were more than 40 acres in size. Four other sections had few fires/million acres, but some were up to 200 acres in size. These 16 sections with low fire frequencies and small fires are in the Alaska Range, Chugach Mountains, Wrangell Mountains, and St. Elias Mountains where much of their area is covered by snow, ice, and rock, or high rainfall along the coast.

In other sections the general pattern is that of many small fires and one or two large fires that account for nearly all the area burned. These sections are in the arctic, or are foothills or lower mountain ranges with considerable area above treeline.

The remaining physiographic sections have experienced a wider range of fire sizes and a much higher frequency of fire (from 26 to 61 fires/million acres/23 years). These sections make up the Northern Plateaus Province and the Western Alaska Province in the center of the state between the major mountain ranges.

Stratification of lightning fire statistical data by physiographic sections will make the data much more useful for fire history studies

Table 3. Lightning fire occurrence and area burned by Physiographic Section, 1957-1979.

Physiographic Section	Area		Lightning Fire Occurrence		Area Burned		Fire Size Acres		Fire Cycle Years
	Million Acres	% Total Area	Number	Number Per Million Acres	Total Acres	% Area	Mean	Range	
1. Arctic Coastal Plain	17.557	5.0	3	.17	8,408	.04	2,802	3-8,400	10,000+
2. Arctic Foothills	28.362	7.9	9	.32	4,148	.01	461	A-4,000	10,000+
3. DeLong Mountains	2.700	.7	3	1.11	10,500	.38	3,500	1,500-4,500	5,000+
4. Noatak Lowlands	4.321	1.2	26	6.02	206,902	4.78	7,958	A-130,000	480
5. Baird Mountains	4.051	1.0	31	7.65	58,455	1.44	1,886	A-30,000	1,000+
6. Central/Eastern Brooks Range	27.281	7.6	61	2.24	191,368	.70	3,137	A-93,330	3,000+
7. Ambler-Chandalar Ridge & Lowland	3.240	.8	103	31.79	524,852	16.19	5,096	A-270,000	142
8. Porcupine Plateau	14.235	4.0	101	7.10	132,220	.92	1,309	A-102,840	2,000+
9. Old Crow Plain	.270	0	0	0	0	0	0	0	-
10. Ogilvie Mountains	2.430	.6	70	28.81	181,857	7.48	2,598	A-46,080	307
11. Tintina Valley	1.008	.3	15	13.89	5,890	.54	393	A-2,600	3,000+
12. Yukon-Tanana Upland	19.988	5.5	424	21.21	701,097	3.51	1,654	A-203,000	656
13. Northway-Tanacross Lowland	1.620	.5	55	34.00	2,987	.18	54	A-1,520	10,000+
14. Yukon Flats	7.562	2.0	213	27.84	361,131	4.78	1,695	A-80,000	482
15. Rampart Trough	.270	.007	13	48.15	1,992	.74	153	1-1,000	3,000+
16. Kokrine-Hodzana Highlands	6.212	1.6	170	27.37	850,919	13.70	5,005	A-251,520	169
17. Kanuti Flats	1.080	.3	66	61.11	843,805	78.13	12,785	A-803,470	29
18. Tozitna-Melozitna Lowland	.810	.2	50	61.73	71,516	8.83	1,430	1-50,000	260
19. Indian River Upland	3.511	1.0	163	46.43	409,920	11.68	2,515	A-140,000	197
20. Pah River	2.970	.8	104	35.02	389,758	13.12	3,748	A-171,000	175
21. Koyukuk Flats	4.862	1.3	167	34.35	1,031,130	21.21	6,174	A-422,000	108
22. Kobuk-Selawik Lowland	6.752	1.8	162	24.00	525,694	7.79	3,245	A-280,000	295
23. Selawik Hills	.540	.2	22	40.74	101,821	18.86	4,628	3-23,000	122
24. Buckland River Lowland	.810	.2	35	43.21	23,110	2.85	660	A-9,850	806
25. Nulato Hills	16.476	4.6	239	14.51	2,204,885	13.38	9,225	A-512,000	172
26. Tanana-Kuskokwim Lowland	9.454	2.6	211	22.32	832,977	8.81	3,948	A-361,600	260
27. Nowitna Lowland	1.890	.5	51	27.00	141,943	7.51	2,783	A-65,000	306
28. Kuskokwim Mountains	19.718	5.5	530	26.88	2,131,093	38.75	4,021	A-644,380	213
29. Innoko Lowlands	3.511	1.0	93	26.49	175,119	4.99	1,883	A-47,000	460
30. Nushagak-Big River Hills	9.454	2.6	63	6.66	184,187	1.95	2,924	A-95,000	1,000+
31. Holitna Lowlands	2.700	.8	14	5.19	293,590	10.87	20,971	A-273,000	212
32. Nushagak-Bristol Bay Lowland	6.482	1.8	23	3.55	49,608	.77	2,157	A-4,500	3,000+
33. Seward Peninsula	13.505	3.8	131	9.70	1,182,894	8.76	9,030	A-270,000	260
34. Yukon-Kuskokwim Coastal Lowland	23.230	6.5	113	4.86	77,975	.33	690	A-10,025	5,000+
35. Bering Platform	6.752	1.9	0	0	0	0	0	0	-
36. Ahklun Mountains	9.454	2.5	9	.95	489	.005	54	2-200	10,000+
38. Aleutian Range	3.240	.9	2	.62	102	.0000	51	2-100	10,000+
39. Alaska Range South	10.264	2.9	11	1.07	228	.002	21	A-40	10,000+
40. Alaska Range Central & East	11.614	3.3	18	1.55	8,189	.07	455	A-8,120	10,000+
41. Northern Foothills, Alaska Range	2.430	.7	15	6.17	1,179,688	48.55	78,645	A-1,161,200	47
42. Cook Inlet-Susitna Lowland	4.262	1.2	19	4.46	5,839	.14	389	A-5,600	10,000+
43. Broad Pass Depression	1.080	.3	2	1.85	2	.01	1	A-1	-
44. Talkeetna Mountains	5.942	1.7	7	1.18	47	.01	7	1-35	-
45. Upper Matanuska Valley	.328	0	0	0	0	0	0	0	-
46. Clearwater Mountains	.270	0	0	0	0	0	0	0	-
47. Gulkana Upland	1.620	.5	4	2.47	704	.04	176	A-700	10,000+
48. Copper River Lowland	5.942	1.7	16	2.69	211	.01	13	A-100	10,000+
49. Wrangell Mountains	3.240	.9	0	0	0	0	0	0	-
50. Duke Depression	.270	0	0	0	0	0	0	0	-
53. Kodiak Mountains	1.350	.4	0	0	0	0	0	0	-
54. Kenai-Chugach Mountains	16.206	4.5	13	.80	118	.01	9	A-100	10,000+
55. St. Elias Mountains	2.700	0	0	0	0	0	0	0	-
56. Gulf of Alaska Coastal	2.160	0	0	0	0	0	0	0	-
Total	357.037	100.0	3,650		15,109,178				
Mean				10.22		6.84	4,140		544

* A = spot fire less than ¼ acre in size

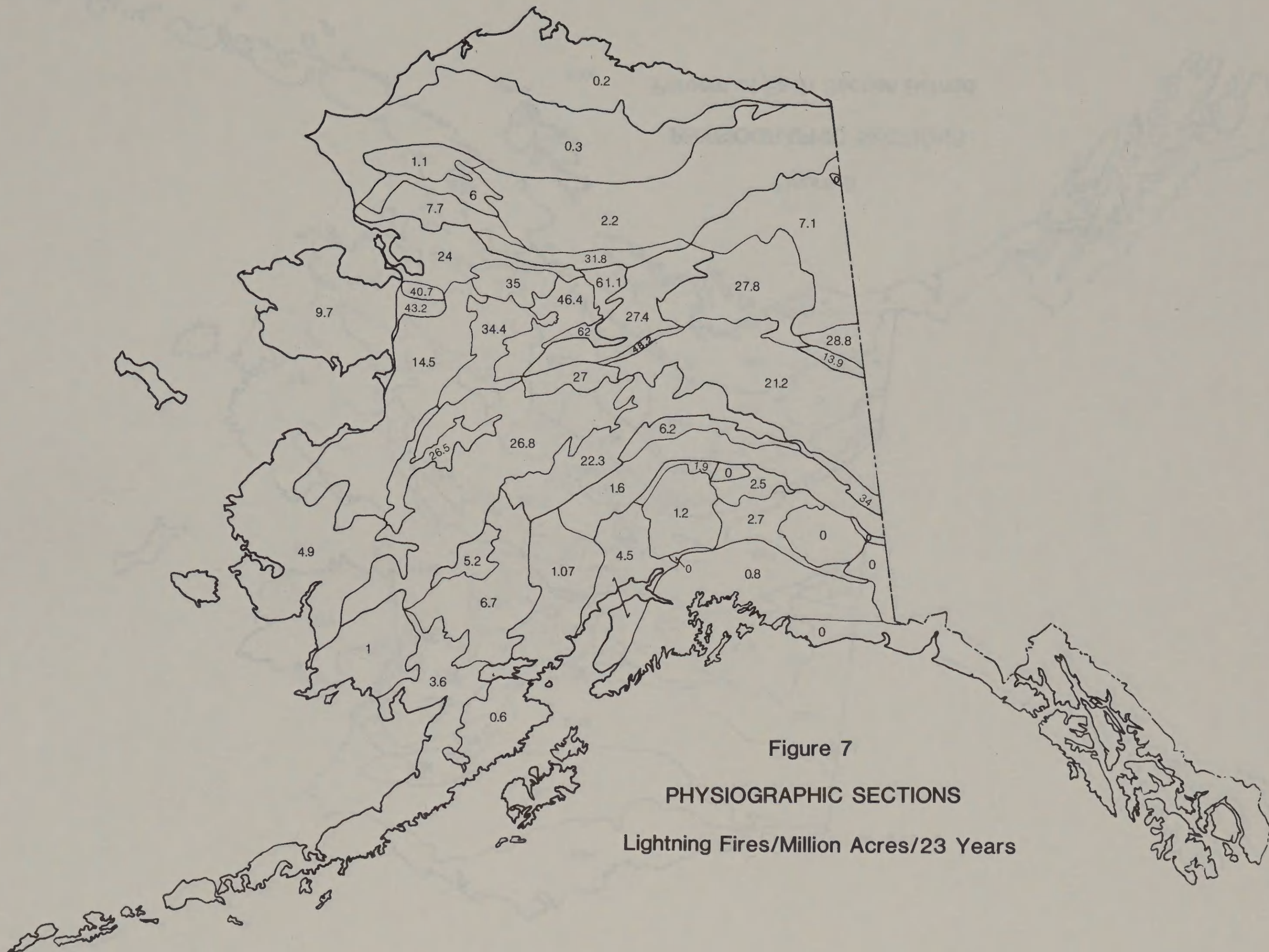

Figure 7

PHYSIOGRAPHIC SECTIONS

Lightning Fires/Million Acres/23 Years

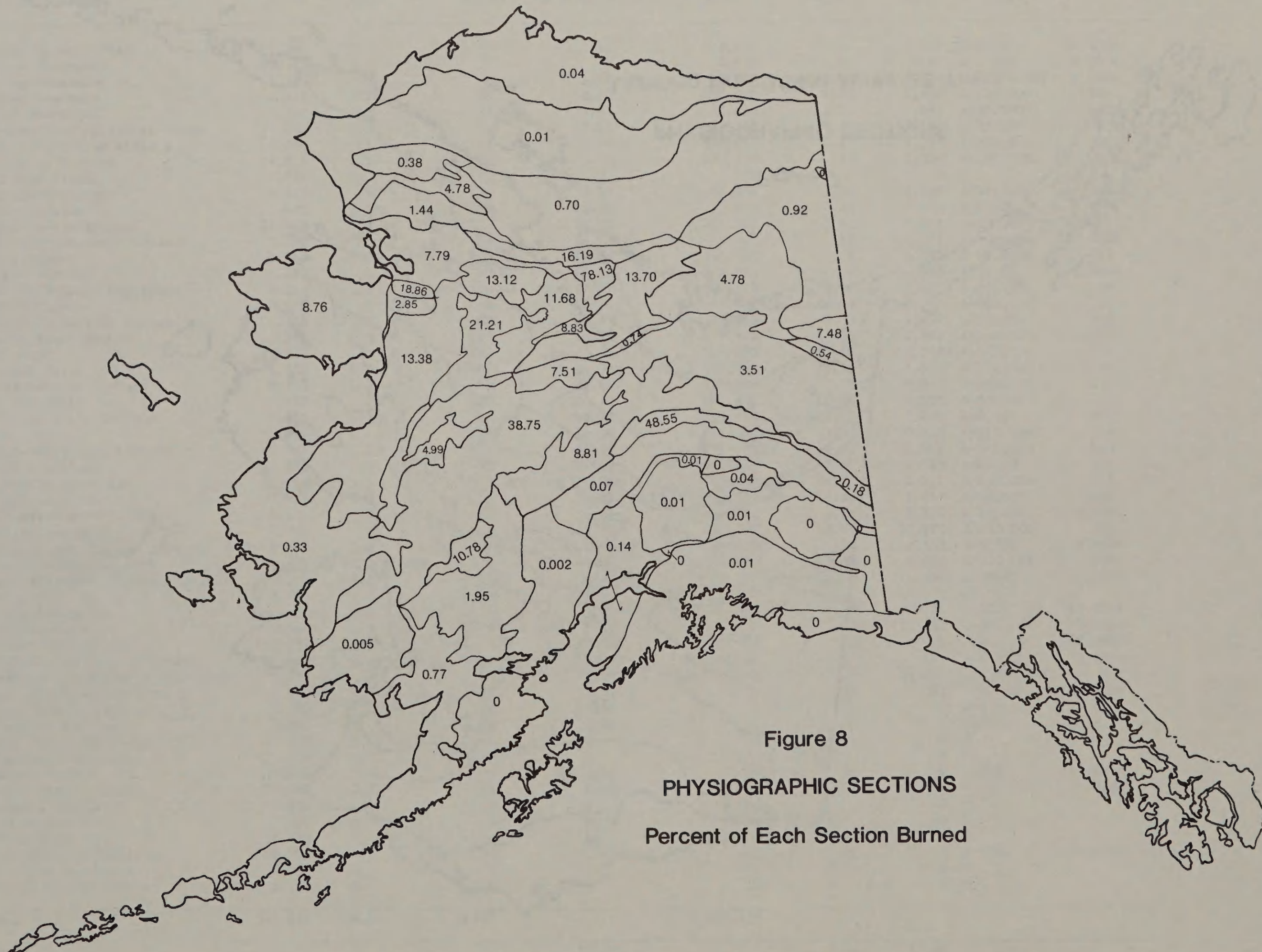

Figure 8

PHYSIOGRAPHIC SECTIONS

Percent of Each Section Burned

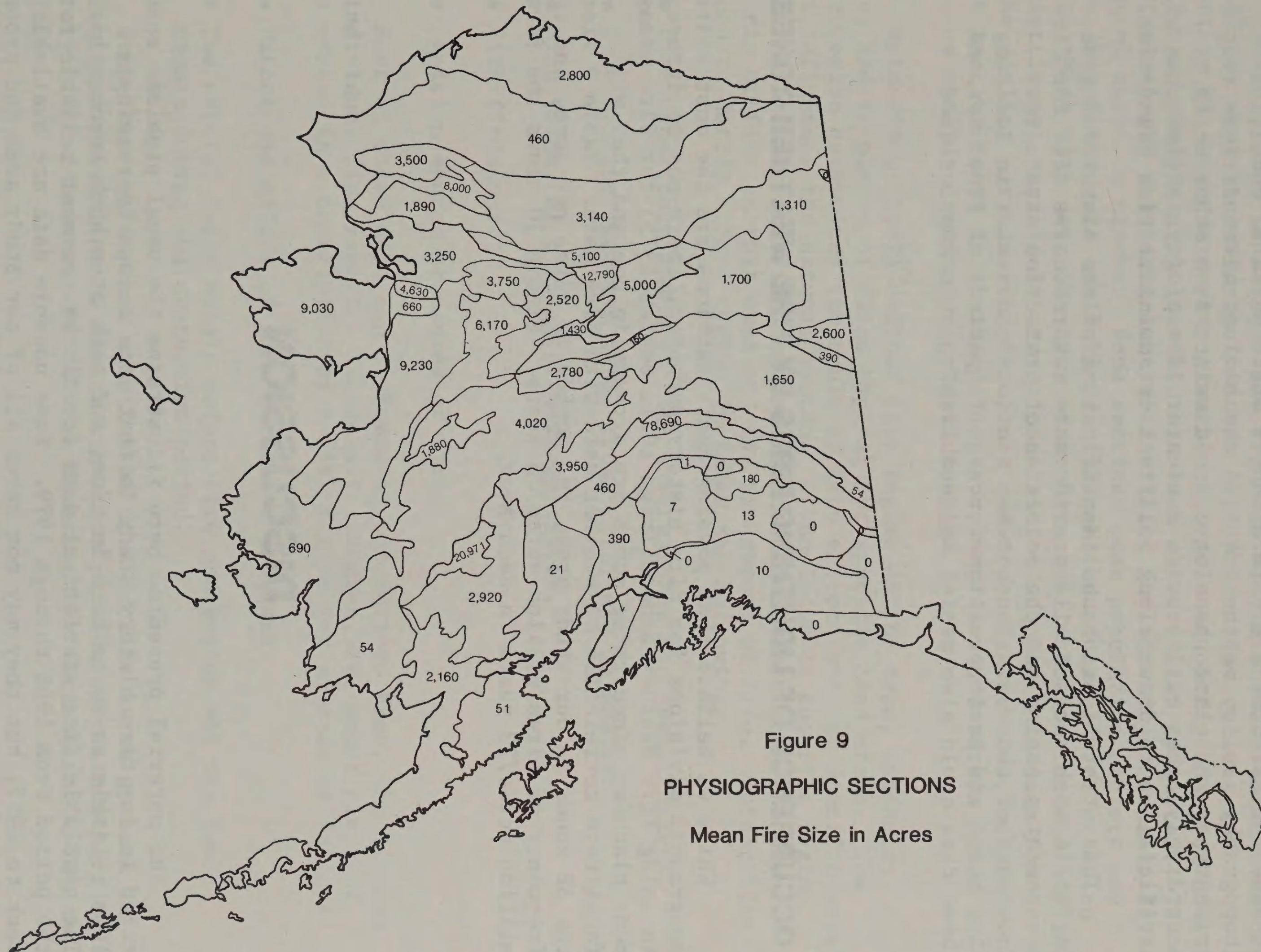

Figure 9

PHYSIOGRAPHIC SECTIONS

Mean Fire Size in Acres

because the sections are natural units where physical conditions (topography, soils, weather, fuels) and biological conditions (vegetation types and plant phenology) are distinct from other units. Accordingly, they will provide a clearer idea of fire regime than will artificial units drawn along political or administrative boundaries.

This stratification and identification of the historical fire regime in each section will provide more comprehensive data for fire management planning and the selection of protection strategies. Knowledge of the variation between sections can assist in locating fire bases and presuppression forces. In periods of fire overload these data could also assist in establishing attack priorities.

OCCURRENCE OF LIGHTNING FIRES BY FIRE WEATHER ZONES

While we believe that physiographic sections are the most suitable geographic divisions for fire history purposes, there may be interest in using Fire Weather Zones (Trigg 1971, Searby 1975) for fire management planning since those zones are already in use and they will facilitate correlation of weather data with fire data. Table 4 lists the 38 zones in our study area, the number of fires per zone, and the frequency of fires/million acres/23 years. Figure 10 shows the fires/million acres/23 years in each zone.

DISCUSSION

The material presented here illustrates the usual problems encountered in any fire history study in that data become increasingly less reliable as we go back in time, and each step back becomes harder. The available fire statistical data for Alaska are most reliable for the period from 1968 through 1979. Some useable data are available back to 1957, but they may not cover all of our study area and probably do not account for all fires during the 1957 to 1967 period. Other general data have been reported back to 1940 but were not useful for this study because of the methods of collecting and reporting those data.

Descriptions of actual fire regimes for the physiographic sections of Alaska must be based on the data available. The quality and quantity of those data vary from section to section depending on how well each physiographic section has been observed and protected. In most cases the only data available will be for the 40 years since fire control began in Alaska. Some sections near population centers may have fragmented data available for the period of settlement prior to 1940. Most will not. We know of no data available now for the earlier presettlement period. It may be possible to acquire some data for those earlier periods from fire scar and tree ring studies, but the tree species found in Alaska do not survive fires and retain scars as well as species elsewhere in North America.

Heinselman (1977) defined fire regime as the type, intensity, size, and frequency of fires typical for specific land areas. The fire regime determines the scale of fire effects and the specific ways fire influences the natural system. A knowledge of the fire regime for a particular area is a necessary antecedent to a study of the effects of fire in that area and the management of fire. Information needed to define a fire regime includes the following:

- Fire occurrence and mean fire interval for the specific area.
- Type of fire (surface fire, crown fire) and intensity.
- Size (area) of typical significant fires.
- Fire frequency.
- Ignition source or causes of fires.

Most of these data can be found in, or derived from, the figures in individual fire reports. There are, however, two other kinds of data needed in a description of a fire regime for an area as follows:

- Extent and effect of fire exclusion programs.
- The natural fuels mosaic before fire protection and the fuel mosaic during the protection period.

Since the quality and quantity of data decline as we go back in time, it is convenient to divide time into periods when studying fire history. The relevant periods were described by (Heinselman 1973) as follows:

- The total period for which there is a record of fire.
- The suppression period during which man has actively suppressed fires and made a record of each.

Table 4. Lightning fire occurrence by Fire Weather Zones, 1957-1979.

Fire Weather Zone	Area Million Acres	No. of Lightning Fire Occurrences	Fires Per Million Acres
1. Arctic	57.876	11	0.19
2. Noatak	10.851	47	4.33
3. Kobuk	8.028	158	20.92
4. Walker	4.177	42	10.06
5. Lockwood	1.515	68	44.88
6. Allakaket	4.136	160	38.68
7. Coldfoot	10.117	116	11.46
8. Seward	10.977	114	10.38
9. Nulato	5.447	105	19.27
10. Galena	7.946	308	38.76
11. Kokime	2.949	110	37.30
12. Ray Mountains	2.785	133	47.75
13. Ft. Yukon	13.926	170	12.20
14. Circle	8.478	205	24.18
15. Kalakaket	3.317	48	14.54
16. Nenana	8.151	207	25.39
17. Livengood	3.891	206	52.95
18. Chena	10.035	189	18.84
19. Fairplay	1.597	48	30.57
20. Tanacross	4.669	60	12.84
21. St Mary's	16.220	94	5.79
22. Unalakleet	7.331	97	13.23
23. Bethel	4.177	38	9.09
24. Tikchik	8.847	11	1.24
25. Innoko	9.175	191	20.81
26. Tatalina	11.427	320	28.00
27. Taylor Mountains	5.365	30	5.59
28. Iliamna	10.649	31	2.91
29. Nikolai	12.001	162	13.5
30. Wein Lake	1.433	50	34.89
31. Skwentna	18.063	32	1.77
32. Mt. McKinley	10.403	37	3.55
33. Mankomen	1.679	4	2.38
34. Kenai	2.662	5	1.87
35. Anchorage	2.662	5	1.87
36. Glennallen	28.869	33	1.14
37. Chugach	3.031	0	0
38. (Kodiak)	0.641	0	0

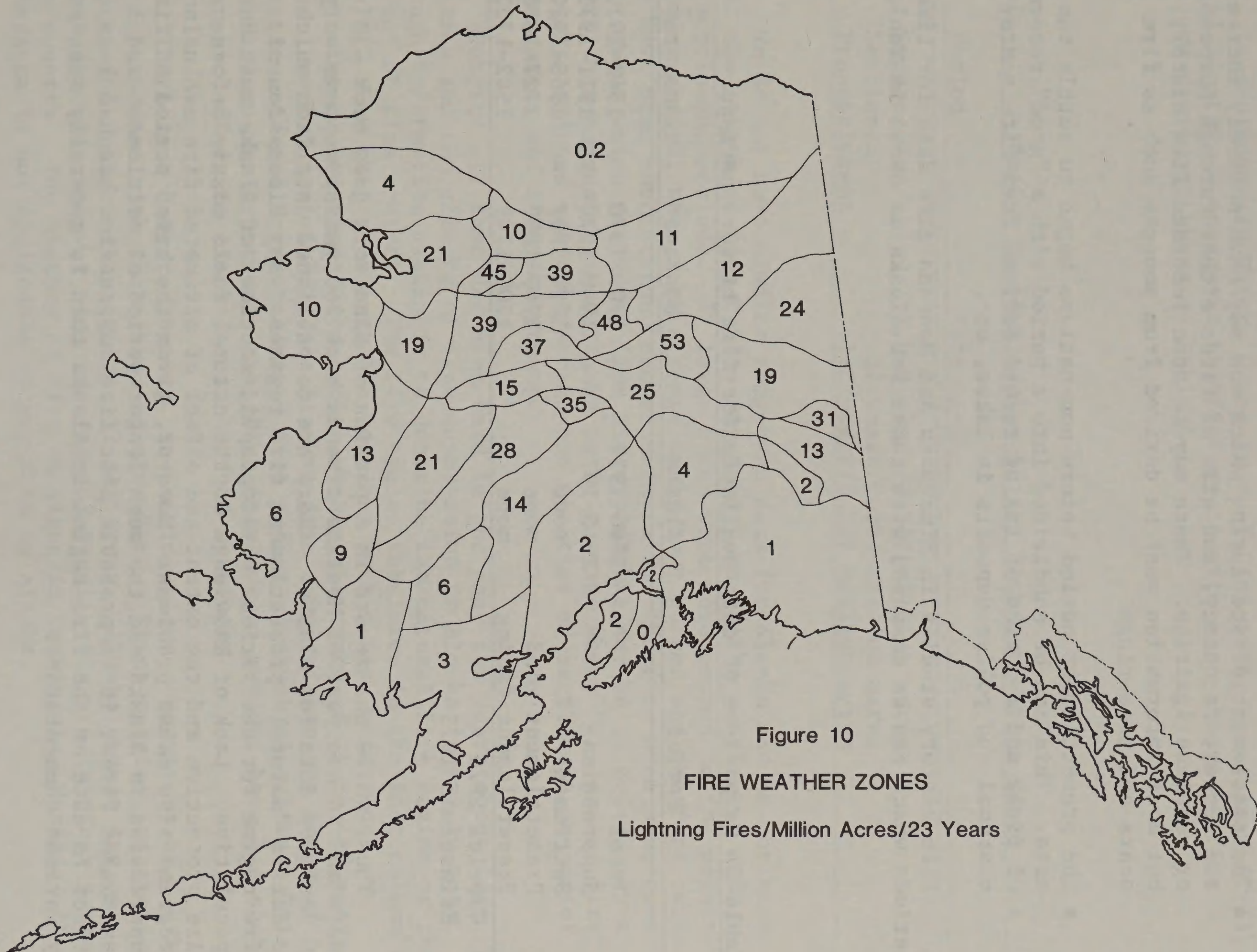

Figure 10

FIRE WEATHER ZONES

Lightning Fires/Million Acres/23 Years

- The settlement period during which man may have actively increased the number, frequency, and size of fires either through purposeful or careless ignition. There may be some recorded fire history, but most information must be derived from sources such as fire scars and tree rings.

- The presettlement period before non-natives began to settle the area. This can be subdivided into a period with a "good" record of fires and a period of fading record derived from fire scars, charcoal and pollen deposits in lakes, etc.

Fire history studies in Minnesota and Montana give data for time periods which can be compared with those for Alaska as shown in Table 5.

Table 5. Comparison of data available for fire history periods.

Period	Alaska	Montana[1]	Minnesota[2]
Total	1940-1979	1709-1970	1542-1972
Suppression	1940-1979	1908-1970	1911-1972
Settlement	none	1890-1907	1868-1910
Presettlement good	none	1749-1890	1727-1868
Presettlement fading	none	1709-1749	1542-1727

[1] Gabriel 1976
[2] Heinselman 1973

Thus, while the record in a portion of Minnesota goes back 430 years and in one part of Montana extends back 260 years, we have only 40 years of data for Alaska. There are no published data from which to derive "natural" presettlement fire regimes. Any discussion of fire regime for the various physiographic sections of Alaska must be speculative. Lack of knowledge of the natural fuels mosaic before fire protection and the extent and effect of attempted fire exclusion programs also cause problems. However, given the brief period of fire suppression in Alaska and the much longer period of settlement and man-caused fires, it is probable that fire suppression has had less effect to date on the fire regime in Alaska than is generally suggested by various commentators.

In the Boundary Waters Canoe Area of Minnesota, Heinselman (1973) could identify a change in the fire cycle with each change in fire history period as shown in Table 6.

Table 6. Change in fire cycles in the Boundary Waters Canoe Area

Period	Fire cycle
Suppression	2,000 years/0.532 million acres
Settlement	87 years/0.532 million acres
Presettlement	122 years/0.532 million acres

We do not have similar long-term data for Alaska and do not know what the length of fire cycles may have been in the settlement and presettlement periods. If large fires were more common in the presettlement period, then more acreage would have burned and the fire cycles may have been shorter than those in Table 3. There is even some question about which period of fire history Alaska may be in today. Pyne (1982) has suggested that Alaska is in a stage where "wilderness fire" prevails and has not yet reached the frontier or settlement phases of development and fire occurrence.

Despite all that has been said in the past few years about fire regimes and the effects of fire suppression in Alaska, there is not enough information available to describe the natural fire regime or the effect of fire control. The fire cycles tabulated in the last column of Table 3 show that physiographic sections with a high occurrence of lightning-caused fires have cycles within the range of 29 to 400 years. Those low figures would place Alaskan fire cyles within the range of "settlement" and "presettlement" fire cycles observed elsewhere. This can lead to the hypothesis that fire suppression may not have had such a dramatic effect in Alaska as it has had elsewhere.

There is a danger, however, in drawing close comparisons of Alaska fire phenomena with those studied elsewhere. Plant species, vegetation types, and fuel continuity are all different. Alaska spruce are not fire resistant the way pine species and Douglas-fir are in other parts of the country. The history of fire on sites in California, Montana, or Minnesota is not applicable to any site in Alaska.

If nothing else, this study calls attention to what is not known about wildfire in Alaska. There may be a correlation of weather patterns and cycles with fire incidence and size, but that remains to be

studied. The influence of one very large fire on the acreage burned in each of eleven of the physiographic sections may also be related to the long-term weather cycles. If the conditions leading to the very large fire can be predicted, it may be possible to plan activities on the basis of both "normal" fire years and "very large fire" years.

We have used only the lightning-caused fire data in this study as a convenient way to illustrate the probable "natural" fire occurrence and frequency within distinct geographical areas. These figures can be used for predictions of the probability of future fire frequency. However, study of the actual fire history in a physiographic section must consider all fires without regard to cause. In fact, it will generally be impossible to determine the cause of fires which occurred prior to 1940 when record keeping began. If man-caused fires are included so that the calculation of fire cycles is based upon all fires of record, the area burned would increase and the fire cycle in each section would be even shorter than that shown in Table 3.

RECOMMENDATIONS

We have demonstrated that the generalized statewide statistics on wildfire in Alaska can be reorganized to reveal regional variations in fire frequency and size. The lightning fire statistics for physiographic sections illustrate the need to look at fire history on a local or regional level and they can be used as a base from which to begin the local fire history studies.

Some may object to dividing the study area into 53 physiographic sections because that seems to be a large number of units to handle. However, the average section size is nearly 7 million acres, and anywhere except Alaska that would be considered a huge area. It is 10 to 20 times larger than the areas included in fire history studies elsewhere.

The physiographic sections are also natural units where physical conditions (topography, soils, weather, fuels) and biological conditions (vegetation types and plant phenology) are distinct from adjacent units. Accordingly, they will provide a clearer idea of fire regime than will artificial units drawn along political or administrative boundaries.

We recommend that the physiographic sections of Alaska be considered as useful units for stratification of data in both fire history and fire management planning. Even when planning must be done within

administrative boundaries, recognition of the sections within the planning area should reveal differences in fire history and fire regime which will be important for planning purposes.

We recommend further that fire history investigations include a study of weather data and the possible correlation between weather and fire history.

Needed now in Alaska are fire history studies which can extend the knowledge of fire dates and sizes back past 1940 and prior to the settlement influence of about 1890.

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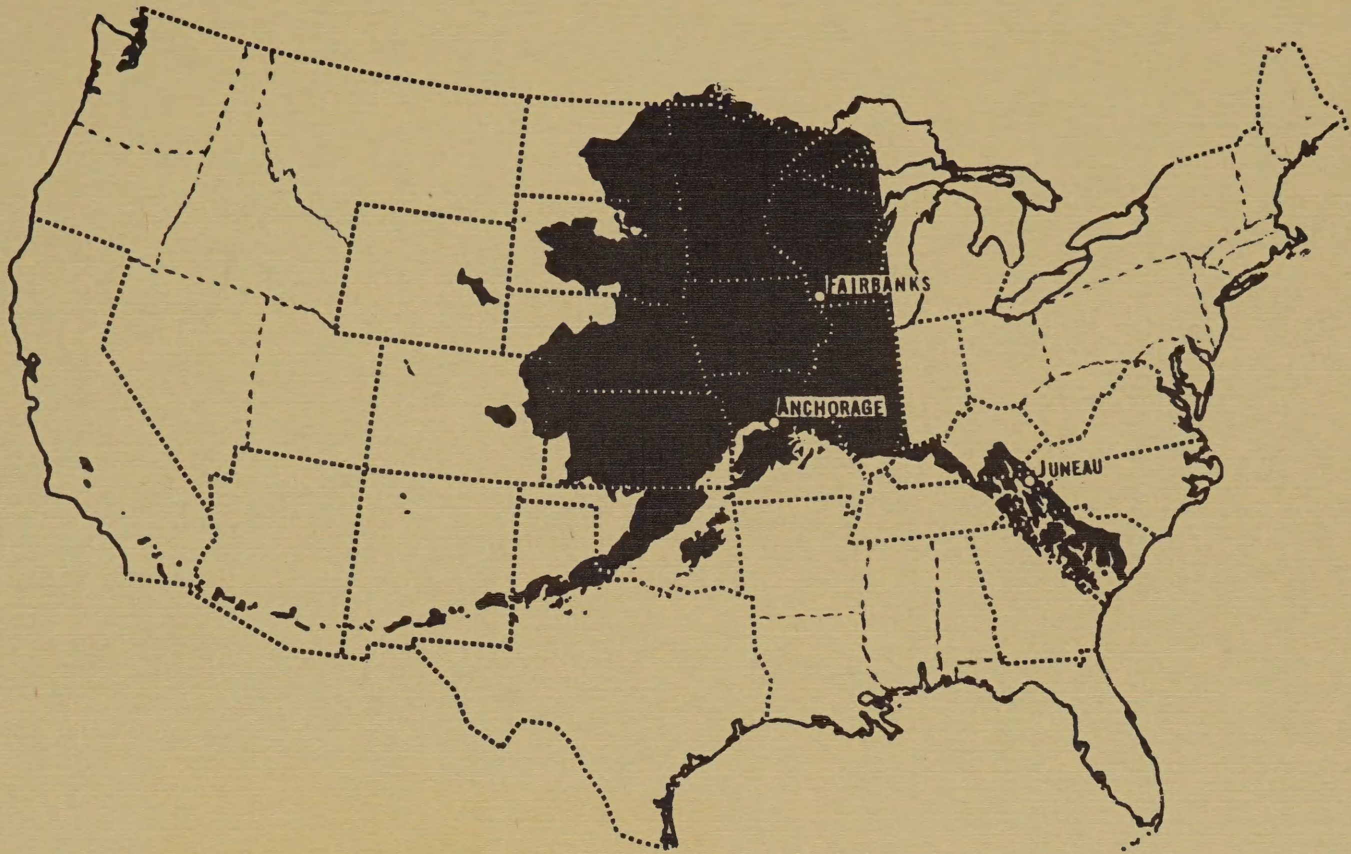

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